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Determination of the main fruit chemical indicators of six apple cultivars in the agro-ecological zone of Deçan, Kosovo

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***Abstract*---**Study was conducted during three consecutive years, 2018-2020, in Deçan of Kosovo. There was studied the expression of the main fruit indicators of six new planted apple cultivars. Mean fruit weight varied from 93.3 g (Gold Delicious clone B) to 184.2 g (Jonagored). Saturn apple cultivar produced the largest size fruit (80 x 84 mm), while Montear Gala produced the lowest size fruit (58 x 70 mm). Fruit dry matter content varies from 14.6% (Saturn and Montear Gala cultivars) to 16.5% (Royal Gala), and 16.7% (Gold Delicious clone B). Fruit sugar content varies from 11.33% (Royal Gala) to 12.7% (Saturn). Total fruit acidity varies from 0.250 mg/100 g fresh fruit (Saturn) to 0.395 mg/100 g fresh fruit (Royal Gala). There were found significative differencies between cultivars for the main tested fruit indicators. There was found a significative relationship between some fruit indicators, as well.

***Keywords*---**apple, content, cultivar, dry matter, fruit, indicator.

Introduction

The apple originates from East Asian countries such as China, Japan and Russia. It belongs to the Rossaceae family, the genus Malus, with more or less similar species that are easily grafted onto each other. The apple belongs to the group of seeds that form false fruits because the flower bed also participates in the process of fruit formation (Çakalli D & Thomai T, 2005; Ferraj B, 2009). Antioxidants found in apple juice help lower cholesterol, prevent cardiovascular disease, and prevent and reduce colon and liver infections. The potassium contained in apples helps regulate blood pressure. Apple fruits do not contain fat, cholesterol or sodium. Apple fruits contain calories, proteins, vitamins A, B1, B2, C and

minerals necessary for human health, such as P2O5, Mg, Fe and K (Zajmi A, 1997). Apple is a plant resistant to low winter temperatures. The most delicate cultivar, the Canada rennet, is damaged if the temperature drops below -27 ^{0} C, while other cultivars tolerate air temperature drops down to -35 ^{0} C. Apple feels the lack of air humidity very much, especially on hot days with temperatures >35 ^{0} C. The best indicator is the length of the growing season, the number of days with an average daily temperature above + 5 ^{0} C (apple's biological zero), which should be above 235 days (Ferraj B, 2013).

According to FAO data, the increase in world apple production in 1990 was 10.7% compared to 1980, while in 2000, it was 36.7% (Zajmi A, et al., 2005). For the breeding and propagation of fruit trees, it is necessary to know as well as possible the way and level of manifestation of their vegetative and productive characters, while the specialization of apple cultivars according to the production destination depends on the chemical composition of the fruit (Shala A , 1995). The cultivar "Red Falstaff" is a clone of "Falstaff" (James Grieve x Golden Delicious), obtained in 1983 in Northfolk, United Kingdom. It has ruby red colored fruit, sweet pulp, juicy, crunchy, with good taste, it is a suitable cultivar for juice production. Jonagored is one of the best Jonagold clones. It has a closed red color, with dark red streaks, taste and aroma of honey, it is stable in storage for a long time (Ferraj B, 2013).

"Delicious i Artë" B has been selected in Holland and is successfully replacing the base cultivar, "Deliciuos i Artë", while "Montear Gala" ripens at the beginning of September, the basic color of the fruit is yellow covered with red, the tree goes into production early and gives regular and high yields (MADA, 2010). Apple cultivars differ among themselves regarding the color, shape and size of the fruit. They also differ in terms of the destination of production, which depends on the content of sugar, dry matter and acidity (Hessayon DG, 2004).

To prove with mathematical precision the existence of differences between cultivars, statistical analyzes of Description and Dispersion (variance) are used, while to prove the degree of connection between the studied traits (vegetative, production traits, etc.), correlation analysis is used, based on biometric indicators and chemical analysis indicators (Susaj L, 2012). In the event that the value of the statistical indicator of variance F-calculated is greater than the table value F-critic, as well as the calculated value of the probability P-value, turns out to be less than the value of the security coefficient $\alpha = 0.05$ (with 95% certainty), we say that we are dealing with two different numerical communities (Papakroni H, 2001).

Material and Method

The study was carried out in the 4-year-old apple orchard, owned by Mr. Bajram Dervishi, in the village of Irzniq in Deçan in Kosovo, in order to determine the average values of the main fruit indicators, such as the average weight, size and chemical indicators of the fruit, in order to spread the best cultivars in the climatic and soil conditions of Deçan. The object of the study were 6 new apple cultivars, Jonagored, Red Falstaff, Saturn, Golden Delicious clone B, Rojal Gala and Montear Gala, grafted on the rootstock with limited growth East Malling 9 (M-

9). The orchard was planted on November 15, 2007. For planting, 2-year-old seedlings with 3-4 developed branches were used. The plants are currently in full production. The measurements for determining the weight and size of the fruits were carried out at the time of harvesting in the field, while the analyzes for the content of water, dry matter, acidity and sugar in the fruit were carried out at the Agricultural Institute of Peja. A "randomized block" scheme was used, with six variants and four replications, with five plants/variant, a total of 120 plants [(6 variants x 5 plants/variant) x 4 replications]. For each variant (cultivar) and repetition, average values of production indicators were measured, analyzed and calculated, such as average fruit weight, based on a sample of 5 kg/cultivar/repetition), average longitudinal and transverse diameter of the fruit (mm), fruit dry matter and moisture content (%), sugar content (%), acidity (mg/100 fresh fruit).

On the basis of these indicators, it was judged for each cultivar in relation to its future in the varietal structure of new apple orchards in the Decan region. In order to increase the accuracy of the conclusions and due to the numerous measurements, the mathematical analysis of the results was used. Description analysis was used to calculate the average value, maximum and minimum values of fruit indicators and the degree of change between cultivars; dispersion (variance) analysis was used to prove the difference between cultivars, while correlation analysis was used to prove the degree of connection between the analyzed traits (Papakroni H, 2001; Susaj L, 2012). On the entire surface of the orchard where the experiment was set up, the same agrotechnology was applied, as a result, the changes in the average values of the measured indicators are changes derived from the characteristics of the cultivar and from the degree of its adaptation to the climatic and soil conditions of the region. Dean.

Results and their discussion

Climatic indicators of the region

From the analysis of climatic indicators, it results that the region of the Decan of Kosovo is very suitable for the cultivation of the above 6 apple cultivars. The average annual air temperature is 12.8 ^{0} C, the coldest month is January with an average temperature of -2.5 ^{0}C and the hottest month is August with 29.8 ^{0}C. The relative humidity of the air fluctuates between 51-83% and is not a concern for apple cultivars. An average of 856.1 mm of rain falls (with irregular distribution) per year. During the June-September period, when the apple has maximum water requirements, only 208.1 mm of rain falls or 23.4% of the annual rainfall. This proves that watering apple orchards is a must. The lowest temperature (in January) in the Decan has dropped to -18 ^{0}C, which does not pose a risk to the apple because it endures up to -35 ^{0}C.

Relative air humidity also favors apple cultivation. The multi-year average value of annual relative humidity is 66.6%. The driest months are July and August, with respective values of 51 and 54%, while the wettest months are December and January, with respective values of 82 and 83% (Table 1). Apples in the Deccan are not at risk from January temperature drops (tmin = -7 ^{0}C) nor from August maximum temperatures (t max = 31.2 ^{0}C).

Table 1. Multi-year average data for climatic indicators of Deçan, Kosovo

V/M	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual average
t_{mes}	-2.5	6.7	11.5	11.3	17.1	21.7	23.3	29.8	15.8	10.6	8.2	2.5	12.8
Humidity air %	82	74	58	62	64	58	51	54	67	70	76	83	66.6
Wind (m/s)	1.1	0.9	0.6	1.4	1.2	1.5	1.3	1.6	0.9	0.8	0.7	1.1	1.1
Rainfall (mm)	37.3	114.5	66.2	57.9	63.6	38.2	23.8	53.2	45.7	47.2	96.5	212	71.4

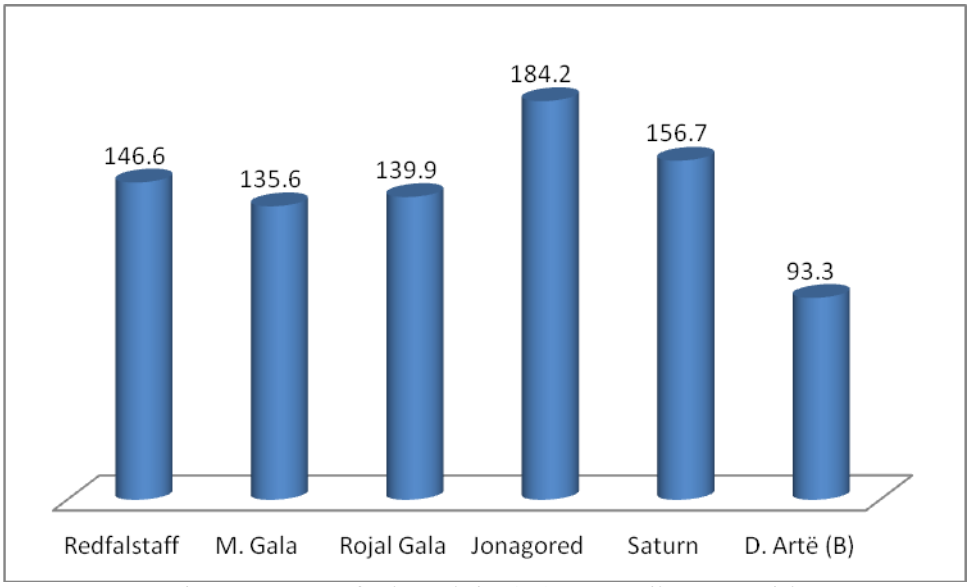
Average weight and average size of fruits, according to cultivars

In order to clarify the behavior and adaptation of the cultivars to the agro-ecological conditions of the Decan, the difference between them due to the production qualities and the destination, the quantitative indicators of the fruit were measured, such as fruit weight (gr), fruit length (mm) and width of fruits (mm). The average fruit weight ranges from 93.3 gr/fruit (Delicious Golden clone B) to 184.6 gr/fruit (Jonagored). The average values of average fruit weight of other cultivars lie within this interval (Table 2, Graph 1).

Table 2. Average values of fruit indicators, according to cultivars

Cultivar	Weight (gr)	Length (mm)	Width (mm)
Redfalstaff	**146.6**	70	66
Montear Gala	135.6	**58**	**70**
Royal Gala	139.9	78	78
Jonagored	**184.2**	77	77
Saturn	**156.7**	**80**	**84**
Delicious i Artë B	93.3	68	73

Average fruit size (mm) varies between cultivars. The highest mean values of fruit size were measured for cultivar Saturn (80 mm x 84 mm), while the lowest mean values were measured for cultivar Montear Gala (58 mm x 70 mm).



Graph 1. Average fruit weight (gr), according to cultivars

The existence of the difference between cultivars for the "average fruit weight" indicator is statistically proven. Specifically, the probability value (P_{-value} = 0.00427) < (α = 0.05), as well as the value (F_{-llog} = 6.12104) > (F_{-crit} = 5.050) (Table 3).

Table 3. Analysis of variance for average fruit weight (ANOVA-test)

Source of variation	*SS*	*df*	*MS*	*F-llog*	*P-value*	*F crit*
Rows (cultivars)	467.75	5	93.55	**6.12104**	0.00427	**5.050329**
Columns	24.083333	1	24.083333	1.57579	0.26484	6.607891
Mistake	76.416666	5	15.283333			
Total	568.25	11				

Chemical-technological indicators of fruit

The Montear Gala cultivar ripens first and ripens on September 10, then the Saturn cultivar ripens and ripens (September 20), while the other cultivars ripen during the period October 10-20. The analyzes of the chemical-technological indicators of the fruits were carried out by the Laboratory of the Agricultural Institute of Peja. The data show that there are differences between the cultivars regarding dry matter content, sugar content and overall acidity, ascorbic acid. The highest level of dry matter has the fruits of the cultivars Delicious i Artë B (16.7%) and Royal Gala (16.5%), while the lowest content has the cultivars Saturn and Montear Gala (14.6%). Cultivars Saturn (12.7%) and Redfal staff (12.4%) show the highest level of sugar content, while the fruits of cultivars Royal Gala (11.33%) and Montear Gala (11.8%) have the lowest content. The cultivars Royal Gala

(0.395 mg/100 g fresh fruit), Jonagored (0.355 mg/100 g fresh fruit) and Delicious Golden clone B (0.314 mg/100 g fresh fruit) show the highest level of total acidity.), while the lowest level is found in the fruits of the cultivar Red Falstaff (195 mg/100 g of fresh fruit). The cultivars Saturn (210.7 mg/kg fresh fruit) and Delicious i Arte B (210 mg/kg fresh fruit) have the highest content of vitamin C (ascorbic acid) (Table 4).

Table 4. Average values of chemical indicators according to cultivars

Cultivar	Humidity (%)	Dry matter (%)	Sugar content (%)	General acidity (mg/100 gr)	Askorbic acid (mg/kg)
Redfalstaff	84.4	15.6	**12.4**	0.275	195
Montear Gala	85.4	14.6	11.8	0.280	230
Royal Gala	84.2	**16.5**	11.33	**0.395**	203.3
Jonagored	83.8	16.1	12.1	**0.355**	206.3
Saturn	85.4	14.6	**12.7**	0.250	**210.7**
Delicious i Artë B	83.3	**16.7**	12.33	0.314	**210**

Differences between cultivars are statistically proven by the results of the statistical analysis of variance (Table 5).

Table 5. Analysis of variance for indicators of chemical analysis (ANOVA-test)

Source of variation	*SS*	*df*	*MS*	F_{llog}	P_{value}	F_{crit}
Rows (cultivars)	**154.1728**	**5**	**30.83457**	**20.8699**	**0.00082**	**2.9012**
Columns)	180503.7	3	60167.91	1697.6	3.3E-19	3.2873
Mistake	531.644	15	35.44293			
Total	181189.6	23				

Comparing the values of the statistical indicators of variance F-llog and P-value, shows that there are statistically proven differences between the cultivars studied, since the values (F-llog = 20.8699) > (F-crit = 2.9012) and (P-value = 0.00082)<(α = 0.05). The statistical analysis of the correlation confirms the fact that between the chemical indicators of the fruit there is a connection and mutual interdependence (the degree of connection between the characters is estimated by the absolute value that the correlation coefficient takes) (Table 6).

Table 6. Correlation analysis for fruit chemical indicators

	Humidity	Dry matter	Sugar content	General acidity	Vit. C
Humidity	1				
Dry matter	**0.94682152**	1			
Sugar content	0.096712108	0.33279427	1		
General acidity	0.59598255	**0.765534453**	**0.76647028**	1	
Vit. C	0.491200817	0.52554071	0.17163714	0.265000444	1

The data show that between such characters as moisture content and dry matter content in the fruit there is a strong correlation (r = 0.95), while between dry matter content, sugar content and total acidity content there is a moderate to strong correlation (r = 0.765 and r = 0.766). There is a weak correlation between the different traits, a fact that is evidenced by the low value of the correlation coefficient.

Conclusion

1) From the analysis of the climatic indicators of the agro-ecological region of the Deccan, it results that the climate is not a limiting factor for the spread and cultivation of the six cultivars included in this study, because the climate indicators of the Deccan are in accordance with the biological features of the apple cultivars.
2) Jonagored, Golden Delicious clone B and Redfalstaff cultivars should have priority in varietal structures, they are the cultivars that have medium weight and good fruit appearance, good content of sugar, total acidity and ascorbic acid (Vit. C), etc., and are more demanded by the market and the consumer.
3) In orchards destined for production for industrial processing, such as fruit juice, compote, etc., the cultivar Jonagored is recommended, due to the large weight of the fruit (>180 gr), high content of dry matter (>16%), total acidity (0.355 mg/100 g fresh fruit) and vitamin C (206.3 mg/kg fresh fruit).
4) The highest content of general acidity and vitamin C is achieved by the cultivars Royal Gala, Delicious clone B and Saturn, for this reason they should be recommended for planting in new orchards destined for fresh fruit consumption.

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